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Efficiency of the Open-Ended Inventory in Eliciting Task Statements From Job Incumbents

Technical Documentary Report PRL-TDR-63-8
March 1963

6570TH PERSONNEL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
Lackland Air Force Base, Texas

Project 7734, Task 773401

(Prepared by
Benjamin Fruchter
Robert E. Morin
and Wayne B. Archer
The University of Texas
Austin, Texas
Contract AF 41(657)274)

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FOREWORD

This manuscript is the final report of an investigation carried out for the Air Force under Contract AF41(657)274 with the University of Texas. The principal investigator was Dr. Benjamin Fruchter, Department of Educational Psychology, University of Texas. The contract was monitored for Personnel Research Laboratory by Major Joseph M. Madden.

On the University of Texas staff, Dr. Robert E. Morin served as Research Scientist and Mr. Jack E. Capehart as Social Science Research Associate. Mrs. Abigail B. Capaldi and Mr. Wayne B. Archer were Social Science Research Assistants.

ABSTRACT

Checklists of tasks included in an Air Force specialty are used to collect job information from incumbents, with provision for them to write in tasks they perform which are not listed. This study investigated methods of selecting incumbents and presenting the checklist to produce the most complete and accurate task inventory. Incumbents of 4 AFSCs (Ground Radio Operator, Automotive Repairman, Aircraft Hydraulic Repairman, Accounting & Finance Specialist) were selected to be representative of commands and geographic location. Portions of the samples were given inventory forms that intentionally omitted some tasks known to be part of the job. From a tally of write-ins, rate of retrieval of omitted tasks and expected production of new task statements were computed for 3 sample sizes (20, 40, 60) within each AFSC. By extrapolating curves fitted to the data, it was estimated that samples of 100 incumbents would yield 85% of the task statements produced by the full sample (360). About 25% wrote in no additional tasks, 50% no more than 3, and only rare individuals over 20. Multiple regression analyses revealed no effective combination of predictors to identify productive individuals. Aircraft Hydraulic Repairmen produced the least, Accounting & Finance Specialists the most new statements. Expanded task inventories were completed by a second sampling of incumbents who rated each task they performed for time required, frequency of performance, and training & experience required. Another series of multiple regression analyses showed that only the number who reported performing a task was highly related to likelihood of a task being written in.

This report has been reviewed and is approved.

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Commander

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EFFICIENCY OF THE OPEN-ENDED INVENTORY IN ELICITING TASK STATEMENTS FROM JOB INCUMBENTS

1. INTRODUCTION

This study is part of a broad program of research in the area of occupational analysis and description sponsored by the Air Force. Morsh & Ratliff (1959) report that occupational analysis "forms part of a continuing progtam designed to improve selection and training standards; to develop efficient and flexible assignment procedures; to provide guide lines for estimation and planning of future manpowet requirements; to establish bases for equable job evaluation; and to provide criteria for promotion or reassignment of personnel" (p. 1).

Job analysis, an important component of occupational analysis, is concerned with the collection, processing, and interpretation of information relevant to the work men do on their jobs. Until recently the principal job analysis procedures employed by the Air Force were group interviews of job incumbents and conferences of technical experts. Morsh, Madden, and Christal (1961) describe newly revised procedures which are expected to improve the quality of job information and the efficiency of its collection.

Under the new procedures a task inventory is the principal instrument. In essence, a task inventory is a list of statements describing the tasks of a particular job. Incumbents provide information by checking tasks they have performed, during a specified period of time, which are part of their regular job. For those tasks which are checked, the incumbent may further indicate how frequently he has performed the task, how long it usually takes, how difficult it is, etc. Furthermore, he is instructed to write in any tasks which he performs which are not included in the existing list.

Morsh *et al.* (1961) consider the merits of the task inventory method in some detail. One of the most important advantages cited is that the method allows for large samples of incumbents to be used on a relatively unrestricted basis. Broad sampling is possible because inventories are essentially self-administering. They can be completed by incumbents in testing rooms or at their worksites.

In an organization as large as the Air Force, with members of any one specialty stationed at bases throughout the world, the feasibility of relatively unrestricted and respresentative sampling is especially important. It is well known that the tasks performed by men within a given specialty may vary markedly as a function of climate, unit mission, base facilities, type of air craft or missile, size of military unit, etc. Restricted sampling may yield a biased picture of the tasks performed within a specialty.

Another advantage of the task inventory method, one related to the first, is its sensitivity to changes in the character of jobs. The Air Force is a dynamic organization in the forefront of technological changes in our society. Jobs change as technology advances. However, changes do not occur at the same rate at all bases and for all specialists. If information is collected directly from men who perform a job, and if an adequate sample of men is selected, it should be possible to update job information almost as rapidly as changes occur.

Purpose of the Present Research

Problems of constructing task inventories and problems associated with the use of completed instruments define two somewhat distinct areas of research. Though the usefulness of inventories is not bound to any one method of constructing them, many of the suggested

advantages of the current Air Force procedures stem from the fact that incumbents are requested to provide information descriptive of the work they do. The central problem of the present investigation was to explore some of the characteristics of this information-giving behavior pertaining to such matters as the attributes of incumbents who provide the greatest quantity and highest quality of information, the number of incumbents needed to obtain the optimum amount of information, and whether or not certain types of work activity information are easier to obtain than others.

Assume that men from a particular Air Force specialty are given a task inventory which is incomplete and does not include all the tasks of their specialty. Will the men write in statements describing tasks they have done which are not included in the existing list? In view of individual differences, it seems certain that the information yield from different men will vary in both quantity and quality. A better way to ask the question would be: How large a sample of incumbents is needed to get a reasonably adequate and complete listing of all the tasks performed in a specialty?

The question of the incumbent sample size necessary to produce various yields of missing task information was central to the present research. However, the investigation was also designed to deal with a number of related problems. The issue of sample size cannot be completely divorced from the question of sample selection. Incumbents will differ in the extent to which they provide useful information. It is important to know whether these differences can be reliably associated with other individual variables which may subsequently be used to select incumbents who will yield the most and the best job information.

Another purpose of the present research was to identify task variables related to the frequency with which tasks are written in by incumbents. Is a task more likely to be recovered if it is difficult or easy? If it is performed frequently or infrequently? If doing the task once takes a long time or a short time? Answers to these questions are essential in the design of procedure statements which are most efficient for use where incumbents provide work activity.

Overview of the Research Procedure

Temporally, the procedures of the investigation may be divided into four phases. During the first phase, four typical specialties were selected for study: Ground Radio Operator (29350), Automotive Repairman (47151), Aircraft Hydraulic Repairman (42152), and Accounting & Finance specialist (67150). For each specialty an initial inventory was prepared from standard Air Force materials describing the specialty. The preparation of the inventories required numerous decisions with respect to the structure and organization of task statements. Criteria for inclusion and exclusion of statements were developed, and an attempt was made to organize statements under general rubrics having applicability beyond the particular specialties studied. Decisions during this phase were facilitated by information from preliminary tryouts.

Three forms of the inventory for each specialty were constructed. One of these, Form 100, contained *all* suitable statements gathered from standard sources. Form 90 was constructed by randomly deleting 10 percent of the statements in Form 100. Similarly, Form 80 contained 80 percent of the statements in Form 100. Deletions were random, but with the restriction that the same statement would not be eliminated from more than one form. The use of the three forms guaranteed that some of the inventories administered to incumbents would be incomplete. It was further intended that recoveries of intentionally omitted statements could then be used as one basis for determining sample sizes necessary to produce inventories of known completeness.

During the second phase of the research, inventories were administered to 360 incumbents in each of the four specialities. One-third of the men in each specialty took Form 100, another third Form 90, and the remaining third Form 80.

The sampling plan allowed selection of bases so as to provide appropriate geographical and command representation among the incumbents. Inventories were mailed to test control officers who arranged for and conducted all testing at the bases selected.

The inventories used during the initial administration contained written instructions directing incumbents to check all statements describing tasks they had performed in the past year. They were further instructed to extend the existing list by *writing in* statements describing other job-related tasks they had performed during that period.

During the third phase of the project, data collected from the initial administration were used to prepare a single revised task inventory for each specialty. Revisions were based upon the write-ins of incumbents. At the same time, rating scales were developed to be administered with the revised inventories. Incumbents rated all tasks they had performed in terms of three dimensions: frequency of performance, average time it takes to do the task once, and the amount of training and experience required to perform the task.

Revised inventories and the rating scales were administered during the fourth phase of the research. This administration was similar to the first in that it was accomplished by mail and through test control officers. Approximately 150 men were tested in each specialty. Some had participated in the initial administration while others had not.

2. PREPARATION OF TASK INVENTORIES

Selection of Specialties

In order to test and establish the generality of results obtained from the investigation, a decision was made at the outset to select specialties from different career fields. The choice of Ground Radio Operator, Automotive Repairman, Aircraft Hydraulic Repairman, and Accounting & Finance Specialist provided one operator job, one office job, and two maintenance jobs.

All data were gathered from five-level airmen, since, men above the five-level normally become supervisors. Five-level airmen probably perform a broader range of tasks than specialists at other levels.

General Rationale Used in the Construction of Inventories for the Initial Administration

Since the research was to be conducted using four different specialties, it was necessary to decide whether to put task inventories for different specialties into a common form. Should statements be similar in structure across specialties, and should a single outline be used to prepare all inventories? It was decided to make inventories for different specialties as similar as possible so long as no obvious injustice was done to the "natural" or customary organization of work within a specialty; it is essential that an inventory appear sensible to the men who take it.

The decision to use the same rules to construct different inventories stemmed from a desire to determine the generality of the findings for particular specialties. Though it is possible that quite different inventories could produce similar conclusions with respect to the major variables of the study and thus establish maximum generality, it seemed more likely

that invariances in the findings would occur if inventories were alike. Furthermore, if inventories from different specialties were idiosyncratic it might be difficult to integrate information across specialties and to serve the purposes of the research.

The attempts to make some general decisions concerning the construction of task inventories may be described in two parts: (1) the definition of a task statement, and (2) the organization of task statements.

Definition of a Task Statement

Dictionary definitions of intelligence tests and intelligence test items would certainly be of some help to the individual who wished to construct an instrument to measure intellectual abilities. However, he would probably profit considerably more from a detailed description of the procedures and rationale used in the construction of existing intelligence tests. The situation is similar when it comes to constructing task inventories. Most suggested definitions for task statements are of the dictionary type. Structurally, a task statement is defined as having a subject, a verb, and an object. The subject is the incumbent himself (I . . .), the verb describes an action (have repaired . . .), and object is the object of the verb (wheel cylinders). So a task statement might read "I have repaired wheel cylinders." Sometimes the subject is left understood and other tenses of the verb are used. In content, a task statement is generally said to describe a worker activity intermediate in specificity between a duty and an element. A duty has been defined as "a large segment of the work done by an individual" (Morsh *et al.*, 1961). McCormick & Tombrink (1960) define a task as "an activity composed of small work units or procedural steps that are closely related to each other and share a common goal, i.e., that are defined by the task itself." The same authors define an element as "one of the procedural work steps involved in a more general activity, e.g., a task. It would appear meaningless for a worker to perform an element solely for the sake of achieving its own outcome."

Definitions like these require considerable elaboration before they become specific enough to be of much help in the construction of a task inventory. In the present investigation it seemed preferable to define a task statement by enumerating some of the large number of decisions made during the construction of the inventories. The decisions are not regarded as model ones; rather, they describe and rationalize, to some extent, part of the procedure used in this study. In many cases good arguments could be offered to support alternative procedures. The following is a discussion of some of the considerations used in arriving at general decisions concerning task statements and the rationale for these decisions.

Problem 1

At a very gross level it is possible to distinguish the *what* and the *how* of the activities men perform as a part of their jobs. Should task statements be concerned with both of these? If so, should they be cast into single or multiple statements?

In many instances the knowledge of what a man does effectively makes information concerning the purpose of the method by which the activity is accomplished redundant. If an electronic technician checks magnetrons, there may be, to all intents and purposes, only one way to perform the task as well as only one reason or purpose for performing it. For instance he may check the tube to see if it works. If however, there is more than one reason for checking, this can be reflected by formulating two task statements such as: checks gas pressure of tube; and checks grid current of tube. The checking may involve a single piece of equipment and a single procedure. On the other hand, information as to how a task gets done may

not be implicit in the statement of the task. The specialist may have considerable latitude in the choice of a method or procedure. Even though a Ground Radio Operator can send messages both by voice and Morse code, it may be important to know whether he does in fact use both methods or how frequently he uses each. Thus a diversity of purposes as well as methods may be expressed by formulating a number of simple task statements.

Granted that information on method and procedures is useful, how shall such information be incorporated into task statement form? The problem is made apparent by considering the four statements below, two concerned with *what* some specialist might do, two concerned with *how* the tasks are accomplished.

WHAT	HOW
1. Calculates correlation coefficients.	1. Uses fully-automatic desk calculator.
2. Does single classification analyses of variance.	2. Uses IBM 650 computer

If one were to use each of these items as the basis for a separate and distinct task statement, it is immediately obvious that some potentially useful information might be lost. It may be impossible to say "how a man does what." The individual who "calculates correlation coefficients" and "uses a fully-automatic desk calculator" may or may not "calculate correlation coefficients using a fully-automatic desk calculator." Only by including statements similar to the last one would information on the conjunction of the *what* and *how* be obtained. Despite the inherent loss of information, it was decided not to include such statements in the inventories prepared for this study. The problem was a practical one of the length of the inventory. If all sensible combinations of *whats* and *hows* were allowed, an inventory could rapidly become of unmangeable length. All possible combinations of just 10 activities with three methods would produce 30 statements. This is contrasted with 13 statements if the two kinds of information are kept separate.

The decision to make separate statements of the *what* and *how* of activities is consistent with the principle that statements be kept simple and as free as possible of qualifying phrases and clauses. One consequence of this decision for each of the inventories was the use of a separate section containing statements on the use of tools and special equipment. So, for example, one statement in the Automotive Repairman inventory read, "I have used micrometers." One in the Accounting & Finance Specialist inventory read, "I have operated printing calculators."

If the Automotive Repairman uses both micrometers and depth gauges it is probably of minimal value to know which measuring instrument is used in performing those tasks in which one or the other is used, especially since there are many source materials such as maintenance manuals which give instructions as to how to perform each task. Although the *how* may not be stated directly in the task statement, it may often be inferred from the list of special tools and equipment used. If there is some special interest in a topic of this kind, a special purpose type of task statement which includes all the necessary qualifying phrases and classes can be used. For most purposes, however, the simple type of statement seems preferable.

Problem 2

A similar problem arose in connection with references to the purposes or *whys* of activities. It would be possible to include in task inventories statements such as: "I have removed jet engines for periodic inspections"; and "I have calculated correlation coefficients for factor

analyses." For the most part such statements were disallowed. The arguments against them are similar to those given in connection with the *how* of activities. Furthermore, in many cases an activity is the same irrespective of the purpose for which it is performed. To compute a correlation coefficient is the same process, whether for factor analysis or for some other purpose.

Frequently the *what* and the *why* of activities are difficult to discriminate. The problem is mixed in with the question of the specificity of tasks. The purpose of an act can frequently be given as the accomplishment of a more general activity. Performance of a periodic inspection may be the reason for removal of a jet engine, but it also is a less specific (more general) activity. If statements such as "I have removed jet engines for periodic inspections" are regarded as undesirable, should two statements be formed, one reading "I have removed jet engines" and the other "I have performed periodic inspections?" The two statements are not of the same specificity. They are not independent in time, but neither are they perfectly correlated. At the present time there is neither a simple nor a completely satisfactory answer to the question of whether both statements should be included in an inventory. The tentative answer which was applied in the construction of the inventories used in the present investigation is discussed in the next section which deals more generally with problems of the specificity of statements.

Problem 3

As was mentioned earlier, efforts to distinguish tasks from other worker activities have focused on distinctions in terms of specificity. Therefore the very name "task inventory" implies that the set of activities described will be fairly homogeneous on a specificity dimension. In the initial stages of construction, considerable effort was devoted to developing criteria of specificity. Though some of the criteria were helpful in the preparation of the inventories, it soon became apparent that a goal of homogeneous specificity (and independent tasks) was not only too constrictive but was also, in some ways, at odds with the purpose of the study.

Following are some examples which illustrate problems of specificity and temporal independence of tasks which a writer of inventories might face. The examples are used as vehicles for explaining decisions and rules of construction which characterized the present investigation.

Example 1. The specificity of a task statement can often be judged in terms of its object. The statement "I have repaired fuel systems" is more general than "I have repaired fuel pumps." Should both statements be included in a task inventory? It was decided not to include both statements, and an attempt was made to maintain some equality of specificity within the narrowly defined sections of the inventory. One section of the inventory for Automotive Repairmen had to do with repairing parts of the fuel system (intake manifolds, carburetors, fuel pumps, air cleaners, governors, etc.). A separate statement was constructed to deal with repairing each of the parts, but no statement on "repairing the fuel system" was allowed.

Example 2. In Example 1 it might be granted that at some low level of organization equality of specificity should be maintained, but it might be asked why the particular level was chosen. Wouldn't it have been adequate to include statements about repairing the fuel system, repairing the electrical system, etc., without going into greater detail? There are two answers to this question. The first, probably of lesser importance, is that statements of the type included (I have repaired carburetors, etc.) seem more consistent with the usual definition of a task. The second answer depends on judgments with respect to the utility of

the information. In some applications, statements such as "I have repaired fuel systems" may provide information exactly at the level of specificity needed. Under such circumstances gathering of more detailed data by the use of very specific statements would be pointless. The general conclusion is that there must be knowledge or judgments about the specificity of information which will be useful. In the absence of such knowledge, an attempt should be made to pitch statements at the level of specificity which will produce a maximum amount of information within the practical limitations set by the ability and available time of the incumbents. Application of these principles is illustrated by the use of the statement "I have inspected fuel systems" in the inventory. This task is probably about equal in specificity to "I have repaired fuel systems" which was rejected for being too general. Behind this apparent contradiction was a judgment to the effect that more specific information on inspection tasks was of little value. This decision was partly a consequence of reading the printed materials describing the job and partly due to interviews with job incumbents. One main reason for trying to include statements of "equal" utility or importance rather than equal specificity is that the latter alternative can add appreciably to the total number of statements in the inventory. If the verb "inspected" had been paired with the same objects as the verb "repaired," the inventory would have been much longer. There are practical limits to the length of inventories. Specialists cannot take unlimited time to complete them. Assuming some fixed time is allowed, stretching out the inventory in sections where information is less important diminishes the time which can be allotted to the sections in which more detail is necessary. The decision, then, was to strive for statements of equal utility in providing information rather than of equal specificity.

Example 3. Another example illustrates the point that activities which are central to a man's job should be handled with statements of greater specificity than activities which are on the fringe or periphery. All of the incumbents in the present investigation were five-level airmen. Men at this level frequently have some supervisory responsibilities, but traditionally supervision is a more important part of the job of seven-level airmen. How much emphasis should be placed on supervisory activities in inventories for five-level specialties? Certainly not as much attention should be given to these tasks as are given them in preparing inventories for specialists whose principal responsibilities are supervisory. The writer of a task inventory gets his initial idea as to the relative importance of various activities from standard Air Force materials describing a specialty. One important feature of the task inventory method is that errors of judgment in this regard are somewhat self-correcting. If the tasks are rated with respect to several attributes (time, frequency, complexity, etc.) by the incumbents to whom the inventories are administered, errors of judgment with respect to the specificity needed in various sections of the inventory should be easy to correct.

Example 4. This example examines further some questions of the specificity and temporal independence of tasks raised in the discussion of the *what, how,* and *why* of activities. At a very early phase in the construction of the four initial inventories, it was decided that there was no point to striving for complete temporal independence of tasks. Different task statements describing the very same "act" or activities which overlap in time are not inherently bad. Consider an "act" of a Ground Radio Operator: he sends a short message. When asked what he was doing, he says, "I just sent some weather information to another station about 50 miles from here, and at the same time I made a record of the transmission in my position log." All of the following statements in the Ground Radio Operator inventory *might* be checked by this man because of the message he sent.

I have handled point-to-point traffic.
I have encoded messages.
I have handled weather information.
I have operated SSB transmitters.
I have used automatic keying equipment.
I have used authentication procedures.
I have transmitted Morse code.
I have maintained radio position log.

If all of these statements were regarded as poor because of temporal overlap and some differences in specificity, the implications are obvious. These problems could be avoided only by forming some complex conjunction of the bits of information into a single statement or by eliminating all but one of the statements. Neither of these alternatives has much to recommend it.

Problem 4

Attempts were made in writing statements to achieve some degree of grammatical conformity. All statements were worded with a first person subject and a present perfect predicate: "I have (*verb*) (*object*)." Modifying phrases were eliminated as much as possible. For example, when a statement in the source materials was found to read "checks fuel system for cleanliness and general operating condition" it was changed to, "I have inspected fuel systems." Wherever possible, statements in the source materials describing knowledge, understanding, or general ability were converted to the standard form. "Understands function and operation of controls on remote control units" was rephrased as, "I have operated remote control units." This change had a purpose beyond grammatical consistency. Statements such as "Understands . . . ." are practically impossible for an incumbent to rate on a time or frequency scale. At the same time, the best indication that an incumbent possesses the required specific knowledge is that he performs the task.

Tasks must have clear beginnings and clear endings if rating is to be feasible. A general effort was made to cast statements into a form in which they would be easy to rate. Another movement in the direction of grammatical consistency is evidenced by the handling of the source statement, "removes and replaces intake manifolds and exhaust manifolds." This compound statement was partitioned into four simple statements:

I have removed intake manifolds.
I have removed exhaust manifolds.
I have replaced intake manifolds.
I have replaced exhaust manifolds.

The decision to split the paired verbs, remove and replace, was a difficult one. Reasonable arguments can be made for leaving them together and for separating them. In maintenance tasks removing and replacing could well be regarded as a part of the same task. Both actions are performed by the same man as a part of a repair operation. However, discussions with specialists prior to the construction of the initial inventories indicated that a linkage between verbs like remove, replace, and repair is not at all necessary even though it is frequently appropriate. Since it was not possible to identify those tasks in which such verbs could and could not be split, they were kept separate.

Problem 5

Statements about activities common to more than a single specialty were standardized. For example, statements in source materials for three of the AFSCs read: "assigns specific tasks to individuals"; "makes assignments in accordance with the abilities of individual workers"; and "assigns work." They were all rephrased to read, "I have made work assignments." This statement was included in the supervisory section of all four inventories.

Organization of Task Statements

There is considerable latitude in the choice of a method for organizing task statements. At one extreme a random arrangement may be used. At the other extreme a very restrictive organization common to all specialties might be applied. In the present study the alternative

of random ordering was quickly rejected. It was felt that a systematic arrangement of task statements would be far more conducive to the detection of missing information by incumbents. Even without a special concern for write-ins, organization should have many benefits. A systematic arrangement of statements should reduce the time necessary for an incumbent to complete an inventory. Furthermore, to the extent that there is communality in the organization from specialty to specialty, successive inventories become easier to write and interspecialty comparisons are easier to make.

The basic organizational format chosen was intended to apply to all specialties. Essentially the format is an outline of all functions performed by five-level airmen. The outline headings were selected after a survey of AFM 35-1 and preliminary work with the four specialties used in the present investigation. Not all of the outline headings apply to all specialties, nor is it assumed that they must occur in a particular order. The major divisions of the outline and a few explanatory phrases and sentences follow.

I. *Inspection.* (Examining; operational checks; tasks usually accomplished in conjunction with routine or preventive maintainence; may inspect materials, equipment, records.)

II. *Diagnosis.* (Interpretation; evaluation; troubleshooting; analytical tasks. Tasks with an emphasis on cognition and problem solving. Examples: map interpretation, troubleshooting, interpretation of interview material, interpretation of data.)

III. *Service.* (As in "service" station. Routine maintainence; preventive maintainence; the "keeping up of . . . ":
   A. Records.
   B. Equipment.
   C. Personal service. (Steward; clerking; providing information or direction to travelers.)

IV. *Correction.* (Corrective maintenance; repair; elimination of malfunctions and errors.)

V. *Construction.* (Building; assembly; fabrication; installation; finishing; collection and preparation of materials; routine building as opposed to creative work.)

VI. *Design.* (Tasks requiring creative work; designing or modification of equipment, materials, and procedures; original writing.)

VII. *Supervision.*
   A. Work Arrangements. (Planning; scheduling; organizing or routing work; making work assignments.)
   B. Training and Guidance. (Classroom and OJT instruction; personal counseling.)
   C. Records, Reports, and Correspondence. (Of a supervisory or administrative nature.)

VIII. *Learning.* (Studying; OJT; technical school attendance.)

IX. *Vigilance.* (Observing; monitoring; watch-keeping.)

X. *Use of Tools and Special Equipment.*

XI. *Processing.* (Processing of information, records, food; to put through a stage of development; to transform; to complete; to handle. Examples: transmitting weather information, cutting meat, typing a manuscript.)

XII. *Special Skills and Procedures.* (Examples: use of Morse code; use of authentication procedures.)

The major divisions of each of the four original inventories are fairly easy to associate with the headings of the above outline. The inventories were divided into sections. For

example. Section I in the original Automotive Repairman inventory was introduced as follows: "This section contains statements about routine or scheduled inspections and operational checks of vehicles and auxiliary equipment." The beginning of Section II reads: "This section contains statements about routine maintenance and servicing of vehicles, auxiliary equipment, and records." These two introductory statements correspond, respectively, to the first and third headings in the outline.

In addition to the grouping of statements into major sections, further divisions were sometimes made among statements within sections. Thus for the Automotive Repairman inventory, statements in Section IV (corrective maintenance) were subcategorized into Part A, Engine; Part B, Fuel System; Part C, Electrical System; etc.

The bases upon which major sections were subdivided were only partly consistent from specialty to specialty, and were necessarily somewhat arbitrary. Categorization depended upon a knowledge of the specialty gained from the source materials. An attempt was made to group tasks in a way which would be regarded as "natural" by incumbents. In the Automotive Repairman inventory, for instance, tasks in the corrective maintenance section could have been grouped under verb headings according to the sort of action performed, such as: Part A, Removal; Part B, Cleaning; Part C, Adjusting; etc. For this AFSC, it was felt that object-grouping would be most appropriate because the repairmen themselves conceptualize their jobs in terms of the equipment worked on, rather than the kind of action performed on the equipment. Verbs describing actions became the basis for a third level of organization in the Automotive Repairman inventory.

It was stated earlier that well-organized as opposed to randomly ordered statements should stimulate write-ins. Two further comments may be made on this point. First, an attempt was made to stimulate write-ins not only by a logical organization of the material but by an "on-the-page" organization. Spaces were provided for write-ins at the end of each group of tasks. This meant that there were spaces on almost every page of all four inventories. When an incumbent contributed a statement, he did not need to write "I have"; at most, he had to write a verb and a noun, sometimes only a noun because the verb was provided. Thus, in the section on corrective maintenance having to do with adjusting parts of the electrical system, spaces for write-ins below this section begin with the words "I have adjusted _____." Another implication of the organization of task statements is particularly relevant to types of write-ins received. If an Aircraft Hydraulic Repairman were working in the section of his inventory having to do with corrective maintenance of power systems, he would find a series of statements having to do with the disassembly of reservoirs, accumulators, pumps, pressure transmitters, etc. The very next section of statements has to do with the repair of the very same components. Still other statements refer to additional actions on these components. It seems highly likely that if a statement like "I have repaired accumulators," were left out of the inventory, its probability of recovery would be higher than other statements for which there were not quite so many cues to jog the incumbent's memory.

Construction of Task Inventories

Preliminary forms of the task inventories were constructed for each of the four specialties selected. These forms were tried out and revised in the preparation of the 80-percent, 90-percent, and 100-percent complete forms for the initial administration.

Automotive Repairman, 47151

The task statements for this specialty were extracted from the following sources:

AF Manual 35-1, 1 March 1956, 47-11 to 47-13
On the Job Training, JP 47151, June 1956
Job Training Standard, June 1956.

In the first *preliminary* form the task statements were organized under major headings such as I. Determination of general condition of vehicle and associated equipment; II. Maintenance of vehicle and auxiliary equipment. This second heading was further subdivided into components such as *A. Engine, B. Fuel System, C. Electrical System.* Each subdivision was arranged in the form of a matrix with verbs such as *inspected and tested, cleaned, removed,* placed across the top, and parts such as *cylinder heads, crankshaft, camshaft,* placed along the side.

Each cell of the matrix contained a small box in the upper right-hand corner which the incumbent was directed to check if he had performed the task during the previous three months. Also within each cell, spaces were available for making three ratings for those tasks which had been performed.

A. The frequency, in terms of number of times per day, week, or month.
B. The average time in terms of hours, minutes, or days.
C. The training preparation which the respondent judged necessary to perform the task proficiently, in terms of the percentage of present level of skill attained at the completion of technical school training.

After each section, space was provided for writing in tasks which the respondent had performed but which were not listed from the original sources. These write-in statements were to be rated in the same way as the provided statements.

This preliminary form was tried out on five-level Automotive Repairman job incumbents. While in general the respondents were able to check and rate the items in a satisfactory manner, very little in the way of write-in statement yield was obtained. This was probably due to the large amount of time and attention required to go through the listed statements and to check and rate them. Also the "difficulty" rating dimension was not entirely satisfactory because it was not clear whether the specialists were making their ratings with reference to time, physical effort, or amount of skill required. The matrix form of presentation of the task statements was not completely satisfactory since the entire matrix could be considered at once rather than each statement individually; sometimes the respondent would skip over an entire section when he might have checked some of the items in the section if they had been presented independently.

The inventory was revised and tried out again on job incumbents. In this revision the statements were organized in the same overall outline as in the first form but they were arranged within subsections serially, rather than in matrix form, so that the task statements would be considered one at a time. In checking each task statement the respondent indicated whether he had performed the task during the previous 3 to 6 months or 6 to 12 months. This scale was used to obtain some indication of the time period it would be best to use for the first administration form. The frequency and average-time rating dimensions were similar to those used in the previous form. The difficulty dimension was changed to a 4-point scale: 0, not at all; 1, slightly; 2, moderately; 3, very difficult. The incumbent was to indicate the nature of the difficulty by checking under one of the following: *Training* or *Experience, Complex, Monotonous, Heavy Work, Rushed, Working Conditions.* Space was provided for any necessary comments to explain the responses or to indicate questions concerning the statements. Again in the administration of this form, although it was satisfactory in most other respects, few

write-ins were obtained. Since a major purpose of the research was to assess the feasibility of obtaining information directly from the incumbents by means of write-ins, it was felt that a revision of the format that would stimulate a greater number of write-ins was needed. One reason for the small yield of write-ins was probably the amount of attention and effort that was directed toward checking and rating the listed statements. A revision of the format that put more emphasis on writing in and less on rating and checking was needed to increase the number of write-ins obtained.

The format of the Automotive Repairman Task Inventory that was adopted for the initial administration was similar to the second preliminary form, except that the three rating dimensions were dropped from this form. It was not necessary to obtain the ratings of the items during the initial administration since the results of the ratings were not needed until the analyses in connection with the second administration. A change in the directions for the initial administration form was made to stimulate more writing in. The incumbent was directed to go through the following three steps in the order listed:

(1) Read each task in the inventory.
(2) Write in all missing tasks you have done during the past year.
(3) Check statements "yes" or "no."

Having the respondent look through the booklet and write in statements which were not listed before he indicated whether or not he had performed the listed task during the preceding year, directed a great deal more attention to the writing-in process. The importance of the writing-in step was emphasized in the directions both to the respondent and to the testing officer. The results of this change of format and emphasis was to produce a larger number of write-ins for the specialty as a whole, although there was a large range of individual differences in the number of write-ins.

Accounting & Finance Specialist, 67150

Three preliminary forms were constructed for this specialty. In the first preliminary form the task statements were obtained from the following sources:

AF Manual 35-1, 1 March 1956, 67-9 to 67-10a
On the Job Training, JP 67150, September 1958
Job Training Standard, September 1958
Specialty Description, September 1958.

The task statements were grouped by verb such as *I have prepared, I have maintained,* and under each verb the forms and procedures, such as vouchers, reports, schedules, were grouped. The respondent was directed to check the last time he had performed the task:

A. within the past 3 months,
B. 3 months to a year ago,
C. more than a year ago,
D. never while at this skill level.

He was also asked to rate the number of minutes needed to complete the task, on the average, and either the number of times the task was done per average week, or per 3-month period. He was directed at the end of each list to look over the listed statements and to write in and rate tasks he had done but which were not listed in that section. Space was provided for comments where necessary either to clarify the statements or his responses. This form was tried out on a sample of incumbents and it was found that the format and directions were clear, but that only a small yield of write-in statements was obtained. From interviews with the specialists,

it was learned that even though accounting and finance are listed under one specialty they had in fact not been merged and individual specialists tended to work in one area or the other.

The second preliminary form benefited from the administration of the first form and also from experience with the inventory for the other specialties. The rating dimensions were dropped and more attention was directed toward obtaining write-ins. The respondent first looked through the inventory without making any response on it; secondly he wrote in the tasks that he had done within the past year but which were not indicated in the appropriate section; and thirdly he checked the task statements he had performed in the past year.

The first administration form of the Accounting & Finance Task Inventory was like the second preliminary tryout form except that descriptions were inserted in the beginning of each section to make clear the kind of tasks included and to be written in that section.

Ground Radio Operator, 29350

Two preliminary forms of the Ground Radio Operator Task Inventory were tried out. The task statements were extracted from the following sources:

AF Manual 35-1, 1 March 1956, 29-21
On the Job Training, JP 29350, November 1958
Job Training Standard, November 1958
Airman Proficiency Test Outline, 1 September 1957.

In the first form statements were classified by headings such as *Types of Messages (Content), Types of Messages (Sources and Destination),* and *Ground Radio Procedures.* Within each section the statements were grouped by verbs such as *I have transmitted, I have relayed, I have received.* The respondent was to indicate whether or not he had performed the task within the past year and to comment either on his responses or on the statements where necessary. In addition to checking the statements, the respondent was directed to write in under each section other tasks he had done which were appropriate to that section but which were not listed.

As a result of the tryout of the first preliminary form, a second preliminary form was constructed which was similar to the first one, except that more categories were added and statements were introduced at the beginning of each section to clarify the nature and scope of the tasks in that section. The first administration form of the Ground Radio Operator Task Inventory was similar to the second preliminary form except for minor revisions.

Aircraft Hydraulic Repairman, 42152

Two preliminary forms of task inventory were constructed and tried out for this specialty. The statements in the first form were obtained from the following sources:

AF Manual 35-1, 1 March 1956, 42-19, 42-20
On the Job Training, JP 42152, January 1956
Job Training Standard, April 1957.

The task statements were organized under major headings such as *Performs preventive maintenance on Aircraft Hydraulic Systems, Performs corrective maintenance on Aircraft Hydraulic Systems.* Each of these major headings was broken down into subsystems such as *A. Power System, B. Flight Control System, C. Actuating System.* The task statements were then grouped by verbs such as *I have inspected, I have cleaned, I have adjusted,* and the respondent indicated whether or not he had performed the task within the past year. At the end of each set of statements space was provided to write in other statements that belonged in the section but were not listed.

The second preliminary form was like the first except for revisions made as a result of the initial tryout and for placing a statement at the beginning of each section to clarify the nature and scope of the tasks included within that section. The first administration form of Aircraft Hydraulic Repairman Task Inventory was similar to the second preliminary form.

3. INITIAL ADMINISTRATION

Sampling

The plan for the initial administration called for 170 copies of each of the three forms to be sent to incumbents in each AFSC. A distribution of frequency of incumbents by command, base, and AFSC was obtained from the major air commands to be sampled. The sampling was set up to be proportional by commands. Consideration was also given to having the northern and southern climatic regions represented approximately equally. It was considered desirable to have all the specialists of a given AFSC stationed at a given base included in the sample to avoid any bias that might be introduced by selection of personnel at the base level.

Sampling was random within the restrictions imposed by commands, AFSCs, and climatic conditions. For the Ground Radio Operator specialty, it was impossible for half of the incumbents to be drawn from each of the two climatic regions in Air Training Command, since almost all of its radio operators were at one base in the southern climatic region, and the number at that base alone exceeded the total number needed from that command.

Summaries of the distribution of incumbents by command and climatic region for each specialty are shown in Table 1. The numbers in the column at the right indicate the frequencies

Table 1. Distribution of Incumbent Samples by Command and Climatic Region

Specialty	Command	Climatic Region		Obtained Total	Proportional N
		South	North		
29350	SAC	71	212*	283	312
Ground	TAC	156	38*	194	165
Radio	ATC	37	0	37	33
Operator	Total	264	250	514	510
67150	SAC	129	139	268	282
Accounting	TAC	48	48*	96	90
& Finance	ATC	82	64*	146	138
Specialist	Total	259	251	510	510
42152	SAC	208	173	381	384
Aircraft	TAC	27	39	66	63
Hydraulic	ATC	32	33	65	63
Repairman	Total	267	245	512	510
47151	SAC	123	161	284	294
Automotive	TAC	65	66*	131	117
Repairman	ATC	57	43	100	99
	Total	245	270	515	510

*All northern bases of command included.

needed in the sample to make its frequencies proportional to the distribution of the specialty in the commands. Since the sampling was done by random selection of bases, rather than individuals, the obtained frequencies are not exactly equal to the proportional frequencies, but as close as could be obtained within the sampling restrictions. The departures from proportional representation by commands are in the direction of the more equal representation of commands rather than in the opposite direction.

The sampling was done separately for each specialty. In each case the sampling was done first in the Air Training Command and the Tactical Air Command since these commands had the most limited distributions by climatic regions, and then the sampling was completed in the Strategic Air Command with an effort to balance the distribution by climatic regions.

Administrative Procedures

Instructions and materials were mailed to the test control officers who administered the task inventories at the bases. In order to perfect the procedure, an initial draft of all correspondence and other materials was sent to the test control officer at a large base in the Air Training Command for his evaluation regarding clarity, appropriateness, etc. These materials included:

A cover letter explaining the nature of the project,
Project Officer's Report on Administration of Task Inventory,
Information Sheet on Specialists,
Sample copies of the task inventories.

A preliminary letter was sent to the test control officer at each base included in the sample to explain the purpose of the research and to determine (a) his correct mailing address, (b) whether the required number of specialists would be available during the testing period, and (c) whether the time period allowed for the testing was satisfactory. A copy of a letter from Command Headquarters authorizing administration of the task inventory was inclosed. Replies to the letters indicated that in most cases fewer specialists were available for testing than were listed in the initial distribution. However, the number available was satisfactory in all specialties except that the number of Ground Radio Operators in Tactical Air Command was less than needed. This deficiency was remedied by increasing the sample of Ground Radio Operators in Strategic Air Command. The number of inventories sent out and the number of completed inventories returned were as follows:

AFSC	Sent Out	Returned
Ground Radio Operator	549	366
Accounting & Finance Specialist	510	394
Aircraft Hydraulic Repairman	580	393
Automotive Repairman	553	398

Nonreturns were due to leave, sickness, special detail, transfer, or temporary duty. Each test control officer returned the inventories, submitted a report on time and place of administration, indicated any special conditions associated with the administration, and prepared an information sheet on each specialist. The information sheet contained an incumbent's Airman Proficiency Test scores and aptitude indexes. In those cases where a man was not available for testing, it gave the reason.

Scoring Returns from the Initial Administration

The returns were scored for two purposes. First, it was necessary to obtain measures of the yield of information from individuals and groups. Secondly, a revised form of the inventory for each of the four specialties was needed for the second administration.

The scoring form for a particular specialty consisted, essentially, of all statements on the original 100-percent form of the inventory plus a collection of new statements derived from the write-ins of incumbents. No reorganization of the original inventories was attempted on the scoring forms. There was never an instance in which an old statement was revised on the basis of new information obtained from incumbents. To have done so would have destroyed the sharp demarcation between old statements, omitted statements, and new statements, and the problems of scoring the write-ins of individual incumbents would have been increased immeasurably. On the other hand, it was possible to let the revised inventories benefit from the organizational changes which seemed reasonable in view of write-ins obtained from incumbents. One of the most important, but not so obvious, benefits from the write-in method is that returns suggest reorganization as well as additions to an earlier form of an inventory.

The raw material available for the preparation of the scoring form for a particular inventory consisted of all the information written in the inventory booklets by the men sampled in a specialty. A good deal of this material is useless information. To illustrate, the 360 Ground Radio Operators provided a total of 186 different new statements. The 186 statements were written in a total of 1259 times, an average of slightly under 7 times per statement. In addition to the useful information obtained from incumbents, there were several thousand write-ins which were not useful for a variety of reasons. One of the principal problems in scoring an inventory is separating out the wheat from the considerable amount of chaff. The useless information takes a variety of forms. Incumbents sometimes write in statements which are already contained in another part of an inventory. They frequently provide information which is too general or too specific. Occasionally write-ins are uninterpretable phrases or words.

The following general procedure was used in the preparation of the scoring forms for each specialty. Initially the individual booklets were inspected and all phrases, possible statements, and comments were numbered. As each booklet was considered, a list of potential new statements was simultaneously prepared. This list was organized like the original inventory. Very little critical screening was done in the preparation of this list, but a statement from a booklet was not added to the list if it was obviously nonsense, if it was a quote of a statement appearing on the original inventory, or if it was a duplication of a statement previously added to the list. The extraction of the statements was done by a single individual. The result of the extraction was a pool of write-in information organized approximately in the form of the original inventory but with overlapping meanings.

Some of the major problems encountered were:

(1) Some statements were at levels of specificity judged to be inappropriate for the inventory. Some were too general; some far too detailed.

(2) Incumbents used terms and phrases which required interpretation by subject-matter experts. In a number of instances, it was not possible to clarify ambiguities even with expert help.

(3) Many contributions of incumbents were in a grammatical form different from that used for statements in the inventory.

(4) Write-ins overlapped one another in meaning and overlapped with items on the 100-percent forms.

(5) Sometimes the statements of incumbents did not fit readily into the organizational scheme of the original inventory.

To clarify the meanings of statements containing ambiguous and unfamiliar terms, members of the project interviewed officers and enlisted personnel familiar with the four specialties. It then became the responsibility of one project member who was highly familiar with the specialty in question to prepare a first draft of the scoring form from the original 100-percent form and

the list of potential new statements. Individuals preparing these scoring forms treated the lists of extracted statements much as the source materials had been treated in the preparation of the original inventories. The raw materials for new statements were frequently combined and reworded. However, new material was never combined with statements which had originally appeared on the 100-percent inventory of the initial administration. After a draft of the scoring form had been prepared by one project member, a second project member made an independent, critical review of the statements. As many points of disagreement as possible were resolved in conference. Differences still outstanding were resolved in conference with a third staff member after he had made independent judgments concerning the points involved.

The scoring of the booklets of the individual incumbents became relatively routine in view of the procedure used in the preparation of the scoring form. A statement on any particular inventory was tagged if it was regarded as sufficient to have prompted inclusion of any of the statements in the scoring form. In other words, it was not necessary for a statement appearing in an incumbent's booklet to be identical to a statement on the scoring form for the incumbent to receive credit for a write-in.

The result of the scoring was an individual-by-statement matrix for each specialty. The statements consisted of all new statements on the scoring form plus statements omitted for any of the subgroups. Entries in the matrices were *0* or *1*, a *one* indicating that a particular incumbent yielded a particular statement. These matrices provided the raw data for the calculation of values of the criterion variables for several of the analyses.

Group Analyses

In order to determine the relationships between the yield of information obtained by the incomplete task inventory method and several variables describing groups and individuals, a series of multiple regression analyses was performed. The first set of analyses examined the relationship between three measures of the yield of job information and various characteristics of a *group*, such as its size, specialty, and the form and completeness of the inventory used by the members of the group. These analyses are referred to as the *group analyses.*

A second set of the analyses sought to determine the relationships between the amount of job information yielded by an individual and various characteristics of the individual, such as his specialty, education, age, rank, aptitude indexes, Airman Proficiency Test score, and the length of time he had been at the five-level of skill. This set of analyses is referred to as the *individual analyses.*

The 36 groups of incumbents used in the group analyses were defined by all possible combinations of the four AFSCs (Ground Radio Operator, Automotive Repairman, Aircraft Hydraulic Repairman, Accounting & Finance Specialist), three check list forms (Form 80, Form 90, Form 100), and three sample sizes (Size 20, Size 40, Size 60). Data were obtained from a total of 1440 men, 360 cases selected from the returns in each of the four specialties. Of the 360 men within a given specialty, 120 completed one of the three forms. To create the 36 groups used in the present analysis, samples of size 20, 40, and 60 were drawn from each of the groups of 120 men who took a particular form of a task inventory. Each individual sample was a random nonreplacement sample. For example, a sample of size 20 from the Ground Radio Operators who took Form 80 contained 20 *different* men. It was possible, however, for the same men to be included in different samples. Thus, a Ground Radio Operator who took Form 80 and was selected for a sample of size 20 could also be selected as a member of a sample of size 40.

Once a single sample had been selected for each of the 36 groups, two additional replications were made. The sampling operations used for the second and third replications were identical with those used with the first. In each new replication there were no restrictions that depended on the outcome of previous sampling. Though all of the group analyses could have been accomplished with a single replication, preliminary work indicated the value of the additional samples. With a single replication there were occasional reversals in the functions relating yield to sample size. At times, due to sampling fluctuation, a large sample produced a smaller yield than a small sample.

Three dependent variables were used in the group analyses. All three measures were derived from the acceptable write-ins of individual incumbents. There were two classes of write-ins: recovered statements and new statements. An incumbent who took Form 80 or Form 90 of an inventory received credit for a recovered statement when he wrote in one of the statements intentionally omitted from these forms. Credit was given for a new statement when a write-in was judged equivalent to one of the new statements on the scoring form. If the rates at which recovered and new statements were written in by incumbents had proved equivalent, the results from both types of statements could have been pooled without analyzing the data of each type separately. Since preliminary analyses suggested different rates of recovery, three dependent variables were calculated to describe yields of information. One of the dependent variables, X_1, was based on both new and recovered statements; a second variable, X_2, was based only on new statements; and the third variable, X_{50}, was derived solely from the intentionally omitted statements.

X_1, X_2, and X_{50} may all be interpreted as proportions. X_1 is the ratio of the length of an inventory obtained from a particular subgroup to the length of the inventory obtained from using all respondenrs. Thus:

$$X_1 = \frac{\text{No. of statements in form the group took} + \text{No. of statements recovered by group} + \text{No. of new statements obtained from group}}{\text{No. of statements in Form 100} + \text{Total of new statements}}$$

Example: A subgroup of 20 Ground Radio Operators took Form 80, recovered 7 statements, and yielded 69 new staremenrs.

$$X_1 = \frac{67 + 7 + 69}{84 + 186} = \frac{143}{270}$$

Variable X_2 was based only on new statements and was determined for a group by dividing the number of different new statements obtained from the group by the total number of different new statements obtained from all 360 men in the specialty. When X_2 was calculated for the first sample of 20 Ground Radio Operators who took Form 80, it equalled 69 divided by 186 or .371. The number of new statements written in by rhe group was 69 and the number of new statements written in by all 360 men was 186.

Variable X_{50} was based on the intentionally omitted statements only. Since no statements were intentionally omitted from Form 100, X_{50} was not defined for groups which took this form. The numerator of X_{50} for a group was the number of differenr recovered statements produced by the group. The denominator was the number of staremenrs which the group might have recovered (the number of statements intentionally omitted from the form in question). When calculated for the same sample of Ground Radio Operators used in the above examples, X_{50} equalled 7/17 or .412. The group recovered 7 of the 17 statements intentionally omirted from the form.

The maximum possible value for X_1, X_2, and X_{50} was *1*. The minimum possible value for X_2 and X_{50} was *0*. For X_1, the minimum possible value was a variable depending on the length of the original inventory and the length of the scoring form. Even if the incumbents within a group provided no write-ins, X_1 would not be 0, since it is essentially the ratio of the length of a revised inventory derived from a single group to the length of the inventory derived from all 360 incumbents. The minimum value for X_1 for each form-specialty combination is indicated in Table 2.

The data used in the multiple regression analyses performed on variables X_1, X_2, and X_{50} are presented in Tables 2, 3, and 4. In Table 2 values of the X_1 criterion appear as a function of sample size for each combination of specialty and form. Ranges of values were .41–.65 for Ground Radio Operators, .59–.77 for Automotive Repairmen, .58–.80 for Aircraft Hydraulic Repairmen, and .40–.69 for Accounting & Finance Specialists.

Perhaps the most immediately striking aspect of these data is that the values are not extremely high. Even when a sample of size 60 was selected, in no case did the value exceed .80. The point of diminishing returns was not reached with samples of size 60. Though it might have been anticipated that 60 specialists would provide sufficient information to obtain a 95-percent complete inventory, 80 percent was the maximum they provided. Increases in sample sizes beyond 60 would have yielded a considerable number of additional unique statements. These findings indicate that there must be statements which have very low probabilities of recovery, since they are written in rarely. If all individual statements had high probabilities of recovery, small samples of incumbents would have been sufficient for high yields of information. At a later point, the distribution of "probability of recovery" for individual statements is examined.

Some of the same general comments which applied to X_1 are appropriately made with respect to X_2 and X_{50} (Tables 3 and 4). Samples of size 60 were not sufficient to produce very high yields on either measure. One value of X_2 was only .09, and the highest value, one obtained with a sample of 60 Aircraft Hydraulic Repairmen, was only .64. The range of X_{50} was from .05 to .78.

At least two sources of evidence point to a difference between new and recovered statements. In the 72 samples for which both measures are defined, X_{50} is greater than X_2 in 18 out of 18 times for Ground Radio Operators, 9 out of 18 times for Accounting & Finance Specialists, 16 out of 18 times for Automotive Repairmen, and 6 out of 18 times for Aircraft Hydraulic Repairman. These two measures correlated only .51.

Table 5 lists the 16 variables used in the group analyses. The first three variables, X_1, X_2, and X_{50}, have already been described. For purposes of these analyses, AFSC became four variables; *Form* became three variables. Variable X_{10} is continuous sample size, and Variable X_{11} is the square of continuous sample size. Three variables are used to define categorical size, and the last variable is the number of items in the 100-percent form of the inventory given to the group in question. The square of continuous sample size was included as a predictor variable in order that the regression equation used in predicting yield as a function of sample size might be quadratic in form. It seemed reasonable that yield should be a negatively accelerated positive function of sample size. The square of continuous sample size was included as a predictor variable to fit the data with part of a parabola.

The intercorrelations of the 16 variables, based on all 108 observations, were computed. Table 6 contains the results of the multiple correlations obtained for the group analyses. The multiple correlation between X_1 and all predictors from X_3 to X_{14} was .935. As might be anticipated, a high multiple correlation of .753 was obtained between AFSCs and X_1. Part of

(Text continues on p. 22)

Table 2. Regression Equation, Obtained Sample, and Minimum Values of X_1

Form	Value Source	Ground Radio Operator Samples			Automotive Repairman Samples			Aircraft Hydraulic Repairman Samples			Accounting & Finance Specialist Samples		
		20	40	60	20	40	60	20	40	60	20	40	60
80-percent	Equation	.46	.53	.59	.61	.68	.74	.60	.67	.73	.47	.54	.61
	Replication 1	.53	.62	.63	.63	.70	.72	.63	.68	.77	.43	.57	.65
	Replication 2	.53	.53	.62	.62	.67	.71	.62	.65	.76	.41	.57	.61
	Replication 3	.46	.52	.61	.59	.66	.68	.58	.63	.74	.40	.50	.58
	Minimum	.25			.51			.41			.26		
90-percent	Equation	.48	.55	.61	.62	.70	.76	.61	.69	.75	.49	.56	.62
	Replication 1	.42	.58	.60	.67	.73	.77	.65	.70	.79	.52	.63	.69
	Replication 2	.41	.57	.57	.66	.69	.76	.65	.70	.75	.47	.59	.68
	Replication 3	.41	.46	.56	.63	.66	.73	.64	.69	.75	.43	.59	.66
	Minimum	.28			.57			.46			.29		
100-percent	Equation	.48	.55	.61	.62	.70	.76	.61	.69	.75	.49	.56	.62
	Replication 1	.51	.54	.65	.68	.72	.72	.67	.74	.80	.48	.59	.62
	Replication 2	.45	.53	.59	.68	.69	.72	.62	.74	.79	.47	.56	.60
	Replication 3	.45	.52	.57	.67	.69	.71	.60	.71	.78	.47	.55	.59
	Minimum	.31			.62			.51			.32		

Table 3. Regression Equation and Obtained Sample Values of the X_2 Criterion

Form	Value Source	Ground Radio Operator Samples			Automotive Repairman Samples			Aircraft Hydraulic Repairman Samples			Accounting & Finance Specialist Samples		
		20	40	60	20	40	60	20	40	60	20	40	60
80-percent	Equation	.25	.37	.47	.15	.28	.38	.35	.47	.57	.27	.40	.50
	Replication 1	.37	.49	.51	.21	.34	.41	.37	.46	.63	.23	.40	.52
	Replication 2	.37	.37	.49	.18	.30	.36	.34	.41	.62	.21	.40	.47
	Replication 3	.27	.35	.47	.15	.27	.34	.26	.38	.55	.19	.31	.44
90-percent	Equation	.25	.37	.47	.15	.28	.38	.35	.47	.57	.27	.40	.50
	Replication 1	.19	.40	.43	.20	.36	.46	.36	.47	.64	.33	.48	.57
	Replication 2	.18	.39	.39	.20	.27	.45	.36	.45	.56	.26	.42	.57
	Replication 3	.18	.25	.38	.16	.20	.38	.34	.44	.54	.21	.42	.53
100-percent	Equation	.19	.32	.42	.10	.22	.32	.29	.41	.51	.22	.34	.44
	Replication 1	.29	.34	.49	.13	.23	.25	.33	.48	.59	.23	.39	.44
	Replication 2	.20	.32	.41	.12	.17	.23	.22	.47	.57	.22	.35	.41
	Replication 3	.20	.31	.38	.09	.15	.21	.18	.40	.56	.21	.33	.39

Table 4. Regression Equation and Obtained Sample Values of the X_{50} Criterion

Form	Value Source	Ground Radio Operator Samples			Automotive Repairman Samples			Aircraft Hydraulic Repairman Samples			Accounting & Finance Specialist Samples		
		20	40	60	20	40	60	20	40	60	20	40	60
80-percent	Equation	.42	.57	.60	.32	.46	.50	.36	.51	.54	.33	.47	.51
	Replication 1	.41	.53	.53	.47	.59	.55	.49	.51	.59	.37	.66	.63
	Replication 2	.41	.53	.53	.30	.50	.47	.43	.47	.57	.29	.55	.58
	Replication 3	.35	.41	.53	.24	.46	.37	.41	.36	.50	.24	.45	.45
90-percent	Equation	.34	.49	.52	.23	.38	.41	.28	.42	.46	.24	.39	.42
	Replication 1	.33	.78	.67	.36	.40	.47	.33	.36	.53	.32	.47	.42
	Replication 2	.33	.67	.67	.26	.28	.45	.31	.36	.53	.16	.37	.42
	Replication 3	.33	.33	.56	.08	.26	.40	.31	.36	.39	.05	.32	.32

Note.—X_{50} is not defined for groups which took Form 100, since the denominator of X_{50} is the number of task statements omitted from a form.

Table 5. Variables of the Group Analyses

Variable	Name	Variable	Name
X_1	New and Recovered Statements	X_8	Form 90
X_2	New Statements	X_9	Form 100
X_{50}	Recovered Statements	X_{10}	Sample Size
X_3	Ground Radio Operator	X_{11}	Square of (X_{10})
X_4	Accounting & Finance Specialist	X_{12}	Sample Size 20
X_5	Automotive Repairman	X_{13}	Sample Size 40
X_6	Aircraft Hydraulic Repairman	X_{14}	Sample Size 60
X_7	Form 80	X_{51}	Number of Items in Form 100

Table 6. Multiple Correlations From Group Analyses

(N = 108)

Variables Included	Content Included	X_1 New & Recovered Statements	X_2 New Statements	X_{50} Recovered Statements[a]
$X_3 - X_{14}$	AFSC, Form, Continuous Sample Size, Categorical Sample Size	.935	.911	.729
$X_3 - X_6$	AFSC	.753	.526	.324
$X_7 - X_9$	Form	.086[b]	.217[b]	.305
$X_{12} - X_{14}$	Categorical Sample Size	.549	.711	.577
$X_{10} - X_{11}$	Continuous Sample Size	.549	.711	.577
Variables Deleted	**Content Deleted**			
$X_3 - X_6$, X_{51}	AFSC, No. Items in Form 100	.722	.846	.653
$X_7 - X_9$, X_{51}	Form, No. Items in Form 100	.931	.885	.662
$X_{10} - X_{14}$, X_{51}	Continuous Sample Size, Categorical Sample Size, No. Items in Form 100	.757	.569	.445
$X_{13} - X_{14}$, X_{51}	Categorical Sample Size, No. Items in Form 100	.935	.822	.433
	Correlation with X_{51}	.698	-.183[b]	-.225[b]

[a] Based on Forms 80 and 90 only, N = 72.

[b] Not significant at .05 level.

this correlation may be attributed to the fact that the minimum value of X_1 is different for diffetent AFSCs. The correlation between Form and X_1 was not significant. The correlation of continuous sample size with X_1 turned out to be reasonably large (.549) and exactly equal to the correlation of categorical sample size with X_1. In fact, the two sets of sample-size variables always correlated identically with each of the criterion variables. This is reasonable as sample size squared is included in the combination of variables called continuous sample size. Since the variable of sample size has only three values, a quadratic equation can define the regression line as adequately as any combination of the categorical variables, X_{12}, X_{13}, and X_{14}. It was observed, however, in the correlation matrix that the correlations of X_{10} with the criterion variables are only slightly less than the correlations when X_{10} and X_{11} are joint predictors.

The lower part of Table 6 shows the multiple correlations obtained when some sets of variables were omitted or deleted. Omitting AFSC had the greatest effect on the multiple correlation. Omission of the sample-size variables had the next greatest effect and resulted in a correlation of .757 with X_1.

Though the general pattern of the correlations of the predictor variables with X_2 and X_{50} was similar to that obtained with X_1, there were a few differences of note. With minor exceptions, the correlations of the predictors with X_{50} were lower than the comparable correlations with X_2. The highest multiple correlation fot X_{50} was .729. The independent contribution of AFSC was smaller for X_2 and X_{50} than for X_1. Undoubtedly this result was associated with the fact that the minimum values of X_2 and X_{50} were not functions of AFSC. Sample size remained an important variable as is shown by the marked reductions in the multiple correlation when the sample-size variables were deleted.

The regression equation obtained from variables X_3 through X_{14} to predict X_1 was used as a basis for obtaining the predicted values of X_1 which are entered in Table 2. Comparable equations were used to predict values of X_2 and X_{50}. Examination of Tables 2, 3, and 4 gives some idea of the adequacy of the fit of the regression lines to the obtained data.

It might be questioned whether the obtained regressions of the yield variables on sample size can legitimately be extrapolated beyond sample size 60. Extrapolation is rarely possible without some qualification, and this case is no exception. The data for samples of size 0 and 360 were not included in the analyses, but values of X_1 (and X_2 and X_{50}) can be determined for samples of these sizes. With samples of size zero, X_1 equals its minimum value; X_2 and X_{50} equal 0. For the samples of 360, upon which the scoring forms were based, X_1 would be very close to 1.00 and X_2 and X_{50} would equal 1.00.

Extrapolations of the regression equations downward in the direction of a sample of size of zero produce some fairly sizable overestimates of the minimum values of the criterion variable; extrapolations upward in the direction of samples of size 360 produce some not very reasonable predictions. As sample size increases, the predicted values eventually reach a maximum and then become a *decreasing* function of sample size. This is understandable if it is recalled that the regression equations of yield on sample size are parabolas. If the purpose of the analysis had been to extrapolate beyond the particular sample sizes employed, some other kind of function would have been preferable. Simple linear functions are one possibility and these might have fitted the data reasonably well, since the functions are very close to linear over the range of sample sizes selected.

In some respects the results of the group analyses were quite unexpected. Most unexpected was the way in which yield of information continued to increase as sample size increased. This finding is expected when there are many statements which have extremely

low probabilities. If a statement is written in only once or twice in a total sample of 360 incumbents, it is apparent that a small sample might not include the individual or individuals who wrote in the statement. Table 7 presents information relative to this point. It shows that, for the totals across specialties, one-fourth of the incumbents produced no new statements, and over a half no more than three statements. Table 8 shows the relative frequency of write-ins of the same statement. Over 30 percent of the new statements are offered by just one man out of the 360. The chances of getting a specific one of those 275 statements from a random sample of 40 incumbents are small. The considerable difference in productivity for men in the four specialties appears in both Tables 7 and 8. Ground Radio Operators and Automotive Repairmen have a lower frequency of write-ins and less duplication of new statements. "Popular" statements were most common in the Hydraulic specialty with about 13 percent of the statements appearing 20 or more times. For the Automotive Repairman and Accounting & Finance Specialties, the comparable figures were less than 5 percent. No statement was ever written in by more than one-third of the men of any specialty.

Table 7. Distribution of Number of New Task Statements One Incumbent Produces

n: number of new statements written in	Number of Incumbents Who Wrote in *n* New Statements				
	Ground Radio Operator	Automotive Repairman	Aircraft Hydraulic Repairman	Accounting & Finance Specialist	Total
0	90	140	81	49	360
1	57	59	23	38	177
2	35	40	24	40	139
3	36	24	25	30	115
4	31	25	15	28	99
5	26	14	18	23	81
6	22	14	14	20	70
7	16	8	19	19	62
8	11	13	13	21	58
9	14	2	10	15	41
10	4	5	14	11	34
11	3	2	9	99	23
12	3	3	8	9	23
13	2	2	5	3	12
14	2	2	7	7	18
15	1	1	10	1	13
16	3	0	4	13	20
17	1	3	5	4	13
18	0	0	3	4	7
19	0	0	3	2	5
20	0	0	1	2	3
More than 20	3	3	49	12	67

Sample Size Prediction

When the regression equations were derived from the group analysis, yield was predicted from AFSC and sample size. Instead of predicting yield, it is possible to set the value of yield and to solve the equation "backwards" for sample size. A computer program was written and numerical solutions were obtained for the case in which X_1 was the criterion variable, and AFSC, Form, Sample Size, and the Square of Sample Size were the predictor variables. A series of criterion yield values (X_1) ranging from .45 to .95 in steps of .05 were inserted in the quadratic equations for each of the 12 combinations of specialties and forms. Then the quadratic equations were solved to give the predicted sample size.

Table 9 shows estimated sample sizes for specified yields of information on variable X_1. In each case, the values of Form 90 and Form 100 are the same since the Form 90 and 100 variables (X_8 and X_9) were not selected in the regression systems. In all specialties, the estimated sample sizes for Form 80 are somewhat higher than those for Forms 90 and 100.

Table 8. Percentage of New Statements Written in a Given Number of Times

n: number of new statements written in	Number of Incumbents Who Wrote in *n* New Statements				
	Ground Radio Operator	Automotive Repairman	Aircraft Hydraulic Repairman	Accounting & Finance Specialist	Total
1	36.56	48.01	22.46	24.16	31.4
2	17.74	19.13	13.47	19.94	17.6
3	7.53	8.30	9.58	11.24	9.5
4	8.06	5.05	7.19	7.30	6.9
5	2.69	6.50	5.99	7.30	6.0
6	2.69	1.81	1.50	4.49	2.8
7	1.61	.36	2.99	3.37	2.2
8	2.15	1.81	3.59	1.69	2.3
9	4.30	.36	2.69	2.81	2.4
10	.54	1.81	2.99	1.40	1.8
11	.54	.72	1.50	1.97	1.3
12	1.08	1.08	1.20	2.25	1.5
13	2.69	1.08	3.59	.56	1.9
14	.54	.00	.60	.84	0.5
15	.00	.36	2.10	.84	0.9
16	.00	.36	1.80	1.69	1.1
17	.54	.00	1.20	1.12	0.8
18	.54	.00	.60	.56	0.4
19	.54	.72	.60	1.40	0.9
20	.54	.00	1.80	.84	0.9
More than 20	9.17	2.52	12.60	4.20	7.0

Table 9. Estimated Sample Sizes for Specified Yields

Subgroup	X_1										
	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95
Ground Radio Operator											
—Form 80	18.2	31.4	46.1	63.0	83.5	112.0					
—Form 90	13.7	26.5	40.5	56.5	75.4	100.0	151.9				
—Form 100	13.7	26.5	40.5	56.5	75.4	100.0	151.9				
Accounting & Finance Specialist											
—Form 80	14.7	27.5	41.7	57.9	77.1	102.4					
—Form 90	10.3	22.7	36.3	51.7	69.6	92.1	127.3				
—Form 100	10.3	22.7	36.3	51.7	69.6	92.1	127.3				
Automotive Repairman											
—Form 80	-15.3	-4.8	6.3	18.4	31.6	46.3	63.2	83.8	112.5		
—Form 90	-19.0	-8.7	2.2	13.9	26.6	40.7	56.7	75.7	100.4	155.7	
—Form 100	-19.0	-8.7	2.2	13.9	26.6	40.7	56.7	75.7	100.4	155.7	
Aircraft Hydraulic Repairman											
—Form 80	-17.4	-7.1	3.9	15.8	28.7	43.1	59.5	79.1	105.3		
—Form 90	-21.0	-10.9	-.2	11.4	23.9	37.7	53.2	71.4	94.5	132.7	
—Form 100	-21.0	-10.9	-.2	11.4	23.9	37.7	53.2	71.4	94.5	132.7	

The differences, however, are relatively small and there is no simple explanation because of the lack of differences between Forms 90 and 100. However, if the proportion of the omitted statements recovered were a constant from form to form, one would expect differences in estimated yield of the type observed in comparing Form 80 with Forms 90 and 100.

The solutions of the quadratic equations indicate the necessity of sample sizes of more than 100 for yields of .75 in the Ground Radio Operator and Accounting & Finance Specialties. Though the situation is somewhat better for the Automotive Repairman and Aircraft Hydraulic Repairman specialties, the estimated sample sizes for a yield of .85 are all close to 100.

In interpreting these estimates, it should be realized that they are based on extrapolations of the regression equation beyond sample sizes for which data were collected. The largest samples actually drawn were of size 60. Sample size estimates larger than 60 should be interpreted with caution because extrapolation becomes more tenuous as estimated sample size increases beyond this point. The necessity for caution is further emphasized by the absence of estimates for several high yield values in Table 9. This is because the parabola defining the regression of yield on sample size becomes a decreasing function somewhere between the last yield for which a tabled sample size is given and the immediately higher yield. When the quadratic equations are solved for sample size, the quantity under the radical is negative for yields beyond the point at which the quadratic becomes a decreasing function.

The negative numbers in Table 9 occur because the yield values which have been substituted in the equation are less than the X_1 values the equation would predict for a sample size of zero.

Individual Analyses

The purpose of the individual analyses was to determine the extent to which certain characteristics of the individual, such as his specialty, the completeness of the form administered to him, the command to which he was assigned, the number of months he had spent in

Table 10. Variables of the Individual Analyses

Variable	Name	Variable	Name
X_{15}	Quantity Index	X_{27}	Months in AFSC at 5-level
X_{16}	Quality Index	X_{28}	Education in years
X_{17}	Ground Radio Operaror	X_{29}	Age
X_{18}	Accounting & Finance Specialist	X_{30}	Rank
X_{19}	Automotive Repairman	X_{31}	Definitely a career airman
X_{20}	Aircraft Hydraulic Repairman	X_{32}	APT score
X_{21}	Form 80	X_{33}	Mechanical AI
X_{22}	Form 90	X_{34}	General or Technical AI
X_{23}	Form 100	X_{35}	Clerical AI
X_{24}	SAC	X_{36}	Electronics AI
X_{25}	TAC	X_{37}	Time to complete inventory
X_{26}	ATC	X_{38}	Months OJT at 5-level

his specialty at the five-level, and a number of background variables such as his education, age, rank, career intentions, aptitude indexes, and achievement scores, were related to the quantity and quality of information which he yielded. Table 10 lists the variables used in the individual analyses. There were two dependent variables in these analyses. The first, X_{15}, was a quantity index which was based solely on write-ins of new statements. For a particular individual, X_{15} was defined as the ratio of the number of new statements he wrote to the total number of different statements written in by the entire sample for his specialty.

A second variable, X_{16}, provided an index of the quality of an incumbent's write-ins. The basic notion underlying the use of X_{16} was that an incumbent who writes in rare statements, ones not likely to be provided by other men, is potentially a good candidate for inclusion in a sample, assuming he can be identified by suitable predictor variables. The definition of X_{16} was revised on the basis of data gathered from the Ground Radio Operator specialty. As originally defined, X_{16} was so highly correlated with X_{15} that it yielded practically no new information. The reason for the high correlation is apparent when the data and the nature of the originally proposed rarity measure are considered. Under the original definition, the incumbent's credit was inversely proportional to the probability of the write-in. If an incumbent wrote in a statement which had been written in by .05 of all of the men within the specialty, he was credited with a value of 1.00 minus .05, or .95, for that statement. A similar value was computed for all new statements which he provided. These were added to form the numerator for X_{16}. The denominator of X_{16} was based upon similar calculations for all the new statements he might have provided; in other words, the total number of new statements obtained from all men in the specialty. It is easy to see how the numerator of this index would be affected if new statements rather generally had low probabilities of recovery and if the probabilities of recovery were relatively homogeneous. In the limiting case of identical probabilities of recovery, incumbents would receive equal credit for all statements. With nearly equal and low probabilities of recovery, the numerator becomes practically identical to number of new statements written in by the incumbents. Since individual statements *were* in general characterized by low and homogeneous probabilities of recovery, this result was obtained.

Several alternative rarity scales were tried out with a view to distinguishing more sharply among providers of rare information. Since few of the statements obtained from any specialty were "very common," and whereas many were "very rare," it seemed appropriate to construct a scale such that the finest distinctions would be drawn among the extremely rare statements. The measure selected was based on a 5-point scale which gave the highest rarity rating to a small group of "most rare" statements, and progressively lower ratings to progressively larger groups of "less rare" statements.

The calculation of the newly defined X_{16}, the one eventually used with all specialties, may be illustrated by a consideration of the Ground Radio Operator specialty. All of the 186 different new task statements obtained were listed in a frequency distribution in the order of the number of times each was written in. The sum of the frequencies for these statements was 1269. The statements were then divided into five groups of unequal size, the largest group (5/15 x 1269) containing the most common statements, and progressively smaller groups (4/15 x 1269, 3/15 x 1269, 2/15 x 1269, 1/15 x 1269) containing statements of progressively greater rarity. The most rare statements were given a value of 5, the least rare a value of 1. Subsequent to obtaining the rating values for each statement, the rarity rating for an incumbent was determined by calculating the mean of the rating values for the statements which he wrote in.

The definition of X_{16} removes to a considerable extent the direct effect of number of write-ins on the value of the measure. In fact, a man who wrote in a larger number of statements

including a few rare statements could get a "poorer" rarity score than another individual who wrote in but a single very rare statement. In this sense, the rarity index is not a pure measure of quality. Such a measure probably exists somewhere between the limits defined by a quantity and a rarity measure.

Information on the background variables was obtained at the time of the initial administration of the inventories. Each incumbent completed an identification sheet giving his command, the number of months he had been at the five-level, his age, educational level, rank, etc. The test control officer filled out an information sheet on each examinee which supplied scores for Airman Proficiency Tests (APTs) and Aptitude Indexes (AIs). Since the records from which this information was obtained were not always complete, values of some of the variables were estimated for some of the incumbents. Approximately 15 percent of the scores had to be estimated on the APT and AI variables to obtain complete data for intercorrelation. The estimation was accomplished by finding another individual who matched the individual for whom the prediction had to be made as closely as possible on the other predictor variables. The corresponding scores of the matched individual were then inserted as a best estimate for the missing values.

Table 11 summarizes the multiple correlations of the predictors with X_{15} and X_{16}. The multiple correlation of all the variables with X_{15} was .464, which indicated only a moderate degree of relationship between the predictor variables and the quantity criterion. The greatest single contribution to overall correlation came from the AFSC variable. When AFSC was deleted, the multiple correlation was reduced to .329, indicating that its contribution was equal to about half of the criterion variance accounted for by all predictors. As a group, the "current information" variables, which included AFSC, form, command, and months in the AFSC, make the largest contribution to the criterion variance. Only a small part of the criterion variance is associated with the remainder of the variables.

Multiple correlations with X_{16} were very small. Even when all variables were used as predictors, the multiple correlation was only .238. No single predictor variable independently accounted for as much as 2 percent of the criterion variance.

The low correlations with variables X_{15} and X_{16} indicate that the predictors analyzed would not be very helpful in selecting individuals who are likely to provide high yields of information. The correlations may be low, in part, because of the relative homogeneity of incumbents on the criterion variables. Many men wrote in no statements, and most wrote in no more than a few (see Table 7). The incumbent who wrote in a large number of acceptable statements was the exception rather than the rule. Perhaps predictors of a different nature should have been tried. The most likely variables are ones related to the potential motivation of the incumbent for the task. Perhaps the greatest number of write-ins are obtained from men who like to fill out task inventories.

4. SECOND ADMINISTRATION

A complete assessment of the task inventory method requires information not only concerning the number of tasks yielded by incumbents, but also concerning the nature of tasks which are performed by incumbents. The principal purpose of this part of the research was to determine the interrelationship of a number of task variables. Are incumbents more likely to write in a statement describing a missing task that is done frequently, that takes a relatively long time to do, or that requires more than average training and experience? If there is a marked relationship between the likelihood of recovering a statement and some of the variables describing the statement, it would be advisable to modify the task inventory to increase the likelihood of obtaining tasks that are done infrequently, take little time to perform, or require little training and experience.

Table 11. Multiple Correlations From Individual Analyses

(N = 1440)

Variables Included	Content Included	X_{15} Quantity Criterion	X_{16} Quality Criterion
$X_{17} - X_{20}$	AFSC	.409	.144
$X_{21} - X_{23}$	Form	.073[a]	.036[a]
$X_{24} - X_{26}$	Command	.026[a]	.003[a]
$X_{21} - X_{27}$	Form, Command, Months in AFSC	.188	.005[a]
$X_{28} - X_{36}$	Background Variables	.213	.156
$X_{37} - X_{38}$	Time to Complete Inventory, Months of OJT	.215	.099
$X_{17} - X_{38}$	All Variables	.464	.238
Variables Deleted	**Content Deleted**		
$X_{17} - X_{20}$	AFSC	.329	.213
$X_{21} - X_{23}$	Form	.460	.234
$X_{24} - X_{26}$	Command	.464	.234
X_{27}	Months in AFSC	.461	.224
X_{28}	Education in Years	.463	.236
X_{29}	Age	.461	.238
X_{30}	Rank	.464	.226
X_{31}	Career Intention	.462	.236
X_{32}	APT Score	.462	.230
X_{33}	Mechanical AI	.464	.234
X_{34}	General or Technical AI	.464	.231
X_{35}	Clerical AI	.464	.221
X_{36}	Electronics AI	.464	.238
$X_{17} - X_{27}$	Current Information Variables	.278	.197
$X_{28} - X_{36}$	Background Information Variables	.441	.195
X_{37}	Time to Complete Inventory	.448	.207
X_{38}	Months of OJT	.464	.238
$X_{37} - X_{38}$	Time to Complete Inventory, Months of OJT	.447	.207

[a] Not significant at .05 level.

Another purpose of this phase was to develop good rating scales for several task rati: factors and to produce revised inventories that present up-to-date pictures of the tasks performed in four Air Force specialties.

The materials used in the second administration were the revised inventories and the task rating scales. The revised inventories differed in several respects from their earlier counterparts. First, they were much longer. The Ground Radio Operator inventory increased from 84 statements on the original 100-percent form to 270 statements on the revised form. The inventories for Automotive Repairman, Aircraft Hydraulic Repairman, and Accounting & Finance Specialist were increased from 474 to 750 statements, 345 to 408 statements, and 177 to 546 statements respectively. The revised inventories had no spaces for write-in statements. The increase in the length of the inventories and the addition of rating scales made it impractical to solicit write-ins. In fact, the original form in which the revised inventories were prepared, proved too long to administer in a single session for three of the specialties. The revised inventories, except for Ground Radio Operator, were divided into a "First Half" and a "Second Half." Different men took different halves. Instructions in the inventory explained that not all tasks in the specialty were included in their booklet, and an outline of the missing half of the inventory was provided.

Three task rating scales were selected for administration with all task inventories. These were (1) a frequency scale, (2) an average-time scale, and (3) a training & experience scale. Several preliminary versions of the scales were tried out prior to adoption of the final scales administered with the revised task inventory. The early versions varied both in content and mode of administration. For example, the scale that finally turned out to be concerned with training and experience was initially a "difficulty" scale. The term "difficulty" was so variously interpreted (e.g., physical difficulty, monotony, complexity) that it was not suitable. The principal decisions with respect to the time and frequency scales centered not so much on the selection of the scale as the mode of asking the incumbents to report the time and frequency spent on tasks. The conclusion from the preliminary research was that it was helpful to permit incumbents to choose their own units in rating tasks on time and frequency. The method by which this was done and the time and frequency scales are apparent from the instructions given to incumbents. These instructions are reproduced in the Appendix.

Rating scales were administered in booklets separate from the revised inventory booklets and separate from each other. For those inventories that were split into two parts, the rating scale booklets were split similarly. During this administration, the inventory was always administered first. Incumbents checked "Yes" next to those statements they had performed during the past year. The three rating scale booklets were administered, in turn, after the revised inventory had been completed.

In sending out the inventories to the test control officers for readministration, a list of incumbents at each base who had taken the initial form was included. It was requested that the same individuals, where possible, be given the readministration form. The test control officer was requested to administer any remaining unused inventories and rating scales to five-level airmen in the appropriate specialties who had not taken the initial form. It turned out that only about half of the returns from the readministration form were from incumbents who had taken the initial form.

The number of booklets upon which the analyses of the second administration were based varied from specialty to specialty and from the first half to the second half of the same specialty. The number of booklets ranged from a low of 66 for the first half of the Accounting & Finance specialty, to a high of 163 for the Ground Radio Operator specialty. The unequal numbers did not affect the analysis of the data.

Variables Used in Analyses of the Task Ratings

The variables used in the task analyses are identified in Table 12. Variable X_{39}, the Task Statement P Value, represents the ratio of the number of incumbents who wrote in a task to the total number who could have written it in. In the case of omitted tasks, the number who could have written it in was equal to 120, the number of incumbents in a given specialty who took a particular form in the initial administration. In the case of new statements, the denominator was 360, the total sample for the AFSC in the initial administration. The second variable, X_{40}, was the percentage of incumbents in an AFSC performing a task. This measure was derived from the data obtained with the revised inventory in the second administration.

Variable X_{41} represents the score derived from the Time ratings. Incumbents rated tasks in terms of the average time necessary to do a task once. To characterize a task in terms of the time factor, it was necessary to convert the responses to a common unit. Ratings on the inventories were in terms of seconds, minutes, and hours. For purposes of analysis, all the time data were converted to seconds.

In characterizing a task on the Time variable, the median was selected as the appropriate measure of central tendency. The reason for choosing medians is apparent from an example which illustrates why the distributions of ratings were sometimes very skewed. Suppose that a Ground Radio Operator is rating a statement like, "I have handled tactical traffic." Most incumbents will react to each transmission of tactical traffic as a separate and distinct event. These men might say that a typical transmission of tactical traffic takes about two minutes. An occasional incumbent, however, will respond by saying "I handle tactical traffic one a day—all day! It takes me 8 hours every time I do it." If this man were to rate a statement on the time dimension with a value of 8 hours and the majority of the people rated the task near 2 minutes it is apparent that a mean of the time ratings would be a poor representation of the data.

The problems with respect to the Frequency ratings, X_{42}, were much the same as with average Time ratings. Responses had to be converted to a common unit and a measure of central tendency, again a median, was computed to summarize the information from different incumbents. All ratings were reduced to number of times per year.

Variable X_{43} was derived from the Training & Experience ratings. Since a simple 4-point scale was used for this factor, a mean was selected as the measure of central tendency for summarizing the information collected from the incumbents.

Obtaining values for all tasks on variables X_{41}, X_{42}, and X_{43}, was itself a laborious job which would not have been feasible without the use of a computer. The routines for calculating means and medians were a part of the program written for the CDC 1604 computer. In one sense, it is better to call the medians which were calculated "middle numbers" since the procedure used in calculating these values was to order all responses and select the middle value when an odd number of observations were available and to average the two middle values when an even number of observations were available for a task. The number of observations on which medians and means were based varied according to the number who reported performing the task.

For the task analyses, only new or omitted statements that were identically worded on the revised form and the scoring form of the inventory were included. The number of statements used for each specialty was:

Ground Radio Operator	215
Automotive Repairman	420
Aircraft Hydraulic Repairman	220
Accounting & Finance Specialist	402

Table 12. Variables of Task Rating Analyses

Variable	Name	Variable	Name
X_{39}	Task Statement P Value	X_{45}	Accounting & Finance Specialist
X_{40}	Percent of AFSC who perform task	X_{46}	Automotive Repairman
X_{41}	Time, in seconds	X_{47}	Aircraft Hydraulic Repairman
X_{42}	Frequency (times per year)	X_{48}	Omitted from Form 80 or 90
X_{43}	Training & Experience Rating	X_{49}	New Statement
X_{44}	Ground Radio Operator		

Table 13. Multiple Correlations From the Task Analyses

(N = 1253)

Variables Included	Content Included	X_{39} task statement P value	X_{40} percent who perform task
$X_{40} - X_{47}$	Item Ratings, AFSC	.507	
$X_{40} - X_{49}$	Item Ratings, AFSC, New vs Omitted statements	.524	
$X_{44} - X_{47}$	AFSC	.338	.320
$X_{48} - X_{49}$	New vs Omitted Statements	.164	.133
X_{39}, $X_{41} - X_{47}$	P-Value, Task Ratings, AFSC		.575
X_{39}, $X_{41} - X_{49}$	P-Value, Task Ratings, AFSC, New vs Omitted Statements		.575
Variables Deleted	**Content Deleted**		
X_{40}, X_{48}, X_{49}	Percent who Perform Task, New vs Omitted Statements	.342	
X_{41}, X_{48}, X_{49}	Time Rating, New vs Omitted Statements	.507	
X_{42}, X_{48}, X_{49}	Frequency, New vs Omitted Statements	.516	
$X_{44} - X_{49}$	AFSC, New vs Omitted Statements	.440	.505
X_{39}, $X_{41} - X_{43}$, X_{48}, X_{49}	P Value, Task Ratings, New vs Omitted Statements		.320

Variables X_{44}, X_{45}, X_{46}, and X_{47} represent the four specialties in the task analyses. Variables X_{48} and X_{49} were used to identify a task as one which had been omitted from either Form 80 or Form 90, or as a new statement obtained from the write-ins of incumbents.

Results of Task Analyses

Variables X_{41} through X_{49} in the task analyses were used as predictor variables. Variables X_{39} and X_{40} were used as both predictor and criterion variables. The multiple correlations obtained with the criterion variables are presented in Table 13.

The highest multiple correlation obtained with X_{39}, the proportion who wrote in a task, was .524. The most important single predictor of recoverability (X_{39}) was the percentage of incumbents who perform a task (X_{40}), with a correlation of .420. The larger the percentage of incumbents who perform a task, the greater the likelihood that it will be written in. The AFSC variables were the next most important predictors, correlating as a set .338 with X_{39}. Time, Frequency, and Training & Experience variables had insignificant correlations with X_{39}. The deletion of these variables from the regression equation had negligible effect on the overall correlation.

When X_{40} was used as the criterion and all the other variables as predictors, a multiple correlation of .575 was obtained. The single most important predictor of X_{40} was X_{39}, the Task Statement P Value with the correlation of .420. Correlations with other predictors are shown in Table 13.

The results of the task analyses indicate that the likelihood that a statement will be written in is relatively independent of the task-rating factors. Apparently incumbents remember tasks, even tasks which they have done infrequently or which take every little time. If a task inventory were a free-recall situation, perhaps incumbents would remember first those tasks which had been done most frequently and those which, on the average, took the longest amount of time. Eventually, however, even less frequently performed tasks would be recalled. Since the task inventory is an aid to recall with a high degree of facilitation of memory coming from the organization of the inventory, tasks low on the frequency and time scales seem to be remembered about as well as tasks higher on these scales.

Incumbents write in only tasks they have performed. It is, therefore, not surprising that the percentage of incumbents who have performed a task is a fairly good predictor of the proportion of incumbents who write in a task.

5. DISCUSSION

The present investigation revealed some useful, interesting, and unexpected information about the task inventory method. Perhaps most unexpected was the finding that the original inventories produced from standard sources describing the specialties were so incomplete. Three forms of the original inventories were prepared, principally to insure that some of the inventories given on the first administration would be incomplete. As it turned out, the number of missing statements was sufficiently large that the study might have been conducted without length of form being used as a variable. The inclusion of Form did emphasize one point. The fact that sizable samples of incumbents were necessary to recover intentionally omitted statements indicated that comparable results with new statements have some generality. If omitted statements had been recovered with relative ease with small samples while new statements required large samples, it might have been suggested that the standards for accepting incumbents' write-ins as statements were too lax.

The obtained data and the regression equations relating the yield measures to sample size were also somewhat unexpected. Over the range of sample sizes from 20 to 60, the regression equations for the group analyses criteria, X_1 and X_2, are nearly linear. There was almost as much gain in yield by increasing a sample from size 40 to size 60 as there was from increasing a sample from size 20 to size 40. For samples of size 60, neither X_1 nor X_2 is close to its upper limit of 1.00.

The reasons for these findings were discussed earlier and are fairly obvious from the data of Table 8. Most of the statements which were written in by incumbents were not written in very many times. In other words, the majority of the statements have low probabilities of recovery. In every specialty, over 50 percent of the statements were written no more than four times. In the Ground Radio Operator specialty, 48 percent of the statements were written in only once.

What is the answer to the question of sample size? Is it possible to use small samples to achieve the same yield of information? It was hoped that the individual analyses would indicate predictor variables making it possible to preselect incumbents who would yield large numbers of statements. The multiple correlations of the individual analyses were too low to indicate much hope for the particular predictors used. The present results, however, should not be regarded as negative with respect to all possible predictors. In retrospect, motivational variables seem a likely basis for selection. As shown in Table 7, a great many men wrote in no acceptable statements. Many men wrote in nothing at all, not even an unacceptable statement. It should be possible to eliminate the large number of men having so little interest in completing the inventory. Part of this lack of interest was due to the newness and experimental nature of the inventory method. An educational program on the importance of the job information and greater familiarity with the procedure would probably reduce the number of men who write in nothing. Changes in the method of administration, such as allowing the incumbents to complete the inventories in their work areas over a period of time, might increase the number of write-ins per individual.

Two further questions might be asked with respect to the adoption of a procedure for selecting incumbents who are potentially most useful in providing information. One question concerns the yield of information if the "best possible samples" had been drawn in the present research. A good approximation of a best possible sample is obtained by examining the responses of the individuals who provided the greatest number of new statements. This was done for samples of size 20 in each of the four specialties. The 20 individuals who wrote in the greatest number of statements in each specialty were selected, and a value of X_2 was calculated for each specialty. These values were:

Ground Radio Operator	.624
Automotive Repairman	.614
Aircraft Hydraulic Repairman	.742
Accounting & Finance Specialist	.621

From these results it is apparent that there is considerable room for selection procedure to increase yield of information. These "best" yields are still considerably below the maximum yield of 1.00, reflecting the fact that many statements are written in by only a few incumbents. The second question is whether a selection procedure would result in biases in the types of information recovered. Such an outcome is always a possibility, but it seems unlikely unless the selection procedure resulted in an unusual distribution of incumbents over bases or geographical areas.

Selection is not the only way in which yields might be increased. In this study, the incumbent was instructed to write in statements describing tasks he had performed *during the past year.* This instruction contained two restrictions, one on time, and the second on experience. A number of men commented that they had performed a large number of the listed tasks but not within the past year. Sometimes men were in school, and sometimes a man's assignment during the past year had restricted his activities to a very narrow part of his specialty. Other men indicated that they had responsibilities which were principally supervisory, and though they had not performed them themselves, they had seen the tasks performed many times during the past year.

It would seem to be a less serious error to fail to delete an outdated task than to fail to include a new task in a specialty. Therefore there might be good reason for permitting men to write in any task which they know to have been performed as a part of the specialty by any man. This suggestion seems applicable only for the phase in which the inventory is being constructed. It would result in the inclusion of some outdated statements, but it should also increase the overall level of yield. The problems associated with this procedure need to be investigated.

Motivational variables have already been suggested as possible bases for selecting incumbents who will provide high yields of information. Motivational techniques might be used to increase the yield of men once they are selected. In the present investigation there were no attempts to indicate to the men who completed the inventories that they were specially selected for their experience and competence. There was no particular pressure to do a good job in completing the inventory. There was no competition, no suggestion that the incumbents must write in at least some statements, and no indication that the kind of effort made was tied to a man's future in the Air Force. There are certain restrictions on the types of incentives that can be given to airmen, but any move in this direction would be expected to improve the yield of information.

6. CONCLUSIONS

Using the task inventory method, a great deal of job information was obtained from 360 incumbents in each of four airman specialties which was not available in source materials such as specialty descriptions, OJT programs, job training standards, and APT outlines. The numbers of task statements extracted from the source materials and from the combination of source materials and incumbents' write-ins were:

Specialty	Source Materials	Source Materials & Write-ins
Ground Radio Operator	84	270
Accounting & Finance Specialist	177	546
Automotive Repairman	474	750
Aircraft Hydraulic Repairman	345	408

The task statements obtained from the write-ins of the incumbents contained significant aspects of the specialties which had not been previously described in the source materials. Some of the new tasks were due to changes in the nature of the specialty or equipment used (such as the shift to EDP equipment and methods in the Accounting & Finance specialty) and other task statements represented important aspects of the specialty which had escaped detection or description by the occupational analysis method previously used.

A number of personal characteristics of incumbents, such as age, rank, proficiency test score, aptitude indexes, education, and length of service were investigated to determine whether any of them would be useful in selecting individuals who would give either a significantly greater quantity or quality of job information. None of the characteristics investigated, either singly or in combination, were related sufficiently to quantity or quality of job information yielded to justify their use for this purpose.

The relationships between several measures of the quantity of job information obtained from a group and the group's characteristics were investigated. The relationships were high, with AFSC and sample size the major factors in the relationships. Regression equations expressing the relationships between sample size and the yield of job information showed that the trend of the relationship was linear, over the range of sample sizes (20 to 60) studied, indicating that the yield of job information would probably continue to increase with increase in sample size beyond 60. This result was related to the low probability of a given task statement being written in.

The relationship between the likelihood that a task statement would be written in by job incumbents and certain characteristics of a task (such as how long it takes to perform a task, how frequently it is performed, the percentage of the specialists who perform the task, and the amount of training and experience needed) were investigated. The most important predictors were the percentage of incumbents who perform a task and the AFSC. Significant differences in the likelihood of a task being written in were present among the four specialties studied. The factors of time to perform, frequency, and amount of training and experience needed to perform the task did not add significantly to the relationship between the likelihood of a task statement being written in and the two most important factors of percentage who perform a task and AFSC.

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Appendix: INSTRUCTIONS FOR RATING TASKS

INSTRUCTIONS FOR TIME RATINGS

For each of the tasks you have done in the past year–those which you checked "Yes" in the inventory booklet–you are to provide information on the amount of time it usually takes to perform the task once.

If you are asked how much time it usually takes to perform a particular task once, you might answer in terms of:

seconds (Sec),
minutes (Min),
hours (Hr).

Choose the most convenient unit for each task. If, on the average, it takes 30 minutes to do a task one time, next to the number for that task you would write:

30 MIN

Use the accompanying sheets to make your ratings.

INSTRUCTIONS FOR FREQUENCY RATINGS

For each of the tasks which you have done in the past year–those which you checked "Yes" in the inventory booklet–you are to provide information on how frequently you have performed the task.

If you are asked how frequently you do a task, how would you answer? You might say:

a certain number of times per hour (Hr),
a certain number of times per day (Day),
a certain number of times per week (Wk),
a certain number of times per month (Mo), or
a certain number of times per year (Yr).

When you rate the task statements in the booklet, for each statement choose the unit which seems best to you. Use the abbreviations shown above. For example, if you want to report that you do a task on the average of three times per week, next to the number for that task you would write:

3 times per WK

Use the accompanying sheets to make your ratings.

INSTRUCTIONS FOR TRAINING & EXPERIENCE RATINGS

Tasks differ in the amount of training and/or experience needed in order to do them proficiently. Some tasks can be done well with relatively little training or experience. Other tasks require considerable schooling or on-the-job learning.

For each of the tasks you have done in the past year–those which you checked "Yes" in the inventory booklet–you are to indicate the amount of training and/or experience required in order to do the task proficiently. Each task is to be rated according to whether

(a) less than average,
(b) average,
(c) more than average, or
(d) considerably more than average

training and/or experience is needed to perform it proficiently.

In rating each task, think about it in relation to all the tasks you have ever done as a part of your specialty.

Make your ratings on the accompanying sheets by checking (X) in the appropriate space next to the number of each task you have done in the past year.

6570th Personnel Research Laboratory, Aerospace Medical Division, Lackland AF Base, Tex.
Rpt No. PRL-TDR-63-8. EFFICIENCY OF THE OPEN-ENDED INVENTORY IN ELICITING TASK STATEMENTS FROM JOB INCUMBENTS. Mar 63, v + 38 p. incl tables. Unclassified Report

Checklists of tasks included in an Air Force specialty are used to collect job information from incumbents, with provision for them to write in tasks they perform which are not listed. This study investigated methods of selecting incumbents and presenting the checklist to produce the most complete and accurate task inventory. Incumbents of 4 AFSCs (Ground Radio Operator, Automotive Repairman, Aircraft Hydraulic Repairman, Accounting & Finance Specialist) were selected to be representative of commands and geographic location. Portions of the samples were given inventory forms that intentionally omitted some tasks known to be part of the job. From a tally of write-ins, rate of retrieval of omitted tasks and expected production of new task statements were computed for 3 sample sizes (20, 40, 60) within each AFSC. By extrapolating curves fitted to the data, it was estimated that samples of 100 incumbents would yield 85% of the task statements produced by the full sample (360). About 25% wrote in no additional tasks, 50% no more than 3, and only rare individuals over 20. Multiple regression analyses revealed no effective combination of predictors to identify productive individuals. Aircraft Hydraulic Repairmen produced the least, Accounting & Finance Specialists the most new statements. Expanded task inventories were completed by a second sampling of incumbents who rated each task they performed for time required, frequency of performance, and training & experience required. Another series of multiple regression analyses showed that only the number who reported performing a task was highly related to likelihood of a task being written in.

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4 Statistical analysis
5 Psychometrics
6 Radio operators
7 Maintenance personnel
8 Accounting personnel
I AFSC Project (Task) 7734(01)
II Contract AF 41(657)274
III U. Texas, Austin
IV B. Fruchter, R.E. Morin, W.B. Archer
V Aval fr OTS
VI In ASTIA collection

6570th Personnel Research Laboratory, Aerospace Medical Division, Lackland AF Base, Tex. Rpt No. PRL-TDR-63-8. EFFICIENCY OF THE OPEN-ENDED INVENTORY IN ELICITING TASK STATEMENTS FROM JOB INCUMBENTS. Mar 63, v + 38 p. incl tables. Unclassified Report

Checklists of tasks included in an Air Force specialty are used to collect job information from incumbents, with provision for them to write in tasks they perform which are not listed. This study investigated methods of selecting incumbents and presenting the checklist to produce the most complete and accurate task inventory. Incumbents of 4 AFSCs (Ground Radio Operator, Automotive Repairman, Aircraft Hydraulic Repairman, Accounting & Finance Specialist) were selected to be representative of commands and geographic location. Portions of the samples were given inventory forms that intentionally omitted some tasks known to be part of the job. From a tally of write-ins, rate of retrieval of omitted tasks and expected production of new task statements were computed for 3 sample sizes (20, 40, 60) within each AFSC. By extrapolating curves fitted to the data, it was estimated that samples of 100 incumbents would yield 85% of the task statements produced by the full sample (360). About 25% wrote in no additional tasks, 50% no more than 3, and only rare individuals over 20. Multiple regression analyses revealed no effective combination of predictors to identify productive individuals. Aircraft Hydraulic Repairmen produced the least, Accounting & Finance Specialists the most new statements. Expanded task inventories were completed by a second sampling of incumbents who rated each task they performed for time required, frequency of performance, and training & experience required. Another series of multiple regression analyses showed that only the number who reported performing a task was highly related to likelihood of a task being written in.

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